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Economic Growth, Law, and Corruption: Evidence from India

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Is corruption influenced by economic growth? Are legal institutions such as the 'Right to Information Act (RTI) 2005' in India effective in curbing corruption? Using a panel dataset covering 20 Indian states for the years 2005 and 2008 we estimate the effects of growth and law on corruption. Accounting for endogeneity, omitted fixed factors, and other nationwide changes we find that economic growth reduces overall corruption as well as corruption in banking, land administration, education, electricity, and hospitals. Growth reduces bribes but has little impact on corruption perception. In contrast the RTI Act reduces both corruption experience and corruption perception.
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INTRODUCTION

Is corruption influenced by economic growth? Are legal institutions effective in curbing corruption? As corruption and economic growth are arguably simultaneously determined, one key question is the issue of causation. Mauro (1995) in his seminal contribution argues that corruption acts as a disincentive for investments and as a result harms growth over the long run. He uses the Business International indices on corruption, red tape, and the efficiency of the judicial system to measure corruption for the period 1980–1983 in 70 countries. In contrast, here we compute corruption using a two-step procedure and Transparency International data.[1] First, we compute an average of the percentage of respondents answering yes to the questions on direct experience of bribing, using a middleman, perception that a department is corrupt, and perception that corruption increased over time for eight different sectors (banking, land administration, police, education, water, Public Distribution System (PDS), electricity, and hospitals). Second, we average these averages over all the eight sectors to generate one observation per state and per time period. A higher value of the corruption measure implies higher corruption.

The advantage of the Transparency International data over any other dataset is threefold. First, the Transparency International data allow us to examine the impact of economic growth and law on corruption in each of the above-mentioned sectors separately. Second, it allows us to make a distinction between corruption perception and corruption experience. Third, it also allows us to separate out the effects of growth on bribing and the use of a middleman. No other datasets would allow us to undertake this empirical exercise. However, the limitation is that it only offers a small sample size relative to cross-country datasets on corruption.

By plotting the data in Figure 1 we indeed observe that economic growth and corruption are negatively related across 20 Indian states and over the period 2005 and 2008. However, the causality could run in both directions. High levels of corruption and weak institutions could reduce growth (Mauro, 1995). In contrast, one can also argue that economic growth creates additional resources that allow a country or a state to fight corruption effectively. Indeed, there is a large literature documenting causality in both directions. Mauro (1995) argues that corruption acts as a disincentive for investments and as a consequence limits growth. Alternatively, rapid modernization of the economy improves institutional quality and makes it easier for the state to detect, monitor, and punish corruption (Lipset, 1960).[2] Furthermore, rapidly growing per capita income also increases the personal opportunity costs of corruption (Treisman, 2000). To address endogeneity we use rainfall as an instrument for economic growth.

[1] Note that Treisman (2000) in Table 1 (p. 411) reports a correlation of 0.87 between Business International and Transparency International macro cross-country data.

[2] Note that Huntington (1968) disagrees with this view. He argues that rapid modernization induces normative confusion at a time when the emerging economic elites are striving for power and influence. As a result growth increases corruption.

Table 1: Summary statistics

Variable	Number of obs.	Mean	Standard deviation	Minimum	Maximum
Corruption [c_{it}]	40	32.3	11.6	16.8	59.1
Corruption in banks [c_{it}^{BANKS}]	40	22.2	12.5	2.3	55.0
Corruption in land admin. [c_{it}^{LAND}]	40	48.8	13.9	19.2	77.3
Corruption in police [c_{it}^{POLICE}]	40	53.4	14.0	14.0	80.8
Corruption in education [c_{it}^{EDUC}]	40	18.9	9.9	3.2	49.3
Corruption in water [c_{it}^{WATER}]	40	29.3	11.95	4.1	54.0
Corruption in PDS [c_{it}^{PDS}]	40	32.4	10.9	10.6	60.3
Corruption in electricity [c_{it}^{ELEC}]	40	30.95	11.7	4.6	57.0
Corruption in hospitals [c_{it}^{HOSP}]	40	30.8	10.9	9.6	57.8
Economic growth [$\hat{y}_{it}$]	40	7.9	4.1	−4.2	16.9
Log rainfall [ln $RAIN_{it-1}$]	40	6.8	0.8	5.4	8.0

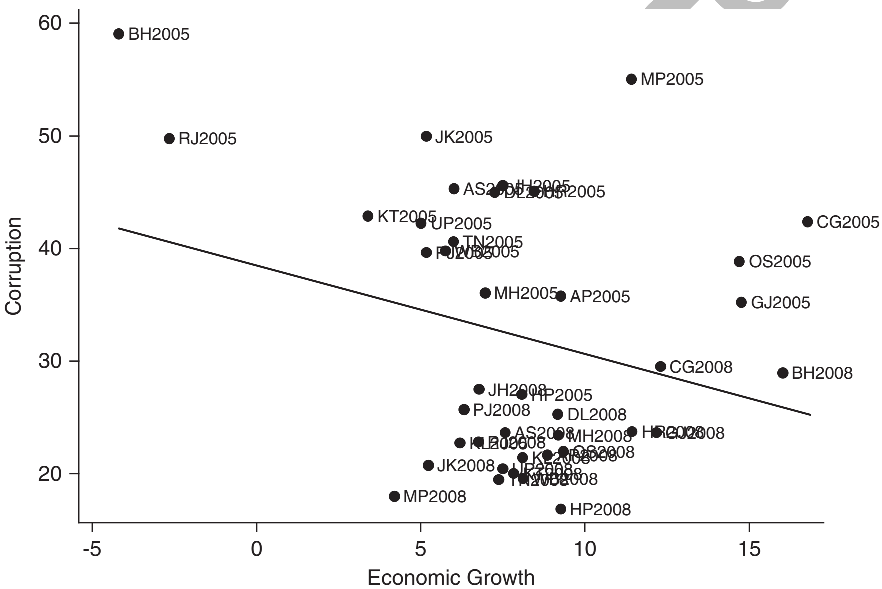

Figure 1: Economic growth and corruption.
Note: State codes are available in the Appendix section ‘Data description’. High value of the corruption variable indicates higher corruption. The t-statistic for the slope of the line is −1.97.

Theory suggests that the causal effects of GDP growth, per capita GDP growth, and GDP levels on corruption could be different. Growth could impact corruption by modernizing institutions and reshaping opportunity costs and personal incentives (Lipset, 1960; Treisman, 2000). The effect could also be non-dynamic with levels of GDP rather than growth accounting for a change in corruption (Hall and Jones, 1999). In this paper we focus on the impact of GDP growth on corruption.

The second key question is how effective legal institutions are in curbing corruption. Our panel dataset on corruption covering 20 Indian states and the periods 2005 and 2008 offers an opportunity to empirically test this effect. The Right to Information Act (RTI) in India came into effect on October 12, 2005, which is after the conclusion of our 2005 corruption survey in January. The act ensures citizens' secure access to information under the control of public authorities. In addition, the accompanying Citizens' Charter makes it legally binding for all government agencies to publish a declaration incorporating their mission and commitment towards the people of India.

An obvious question is how RTI in India is linked to corruption. It is quite common in India that citizens visiting some government offices for certain legitimate services would either be not listened to or would be given a vague response. On many occasions the officials would raise irrelevant objections to simple applications for water connections. The government officials would resort to such tactics because they are either seeking a bribe or hinting that the citizen should pay a corrupt middleman to get the job done. Without these payments, the application would be delayed under flimsy verbal objections from the official.[3] RTI empowers citizens to write a letter to the Public Information Officer (PIO) of the relevant government department seeking answers to questions such as why the application for a water connection is delayed. Under the RTI Act the citizen is also entitled to ask for a daily progress report on the water connection application, the names and designations of officials with whom the application is lying during the time under scrutiny, proof of receipt and dispatch of the application from the office of each of these officials, what is the maximum time limit according to the departmental rules for a water connection application to be processed, if these rules are violated then which official is responsible, an official assessment report on the possible violation of the published model code of conduct of the department, and, if a violation has occurred, then what action would be taken against the guilty. In the event of a citizen writing such letter to the PIO, it becomes extremely difficult for the department to provide answers to such probing questions within the RTI time limit without taking action against the responsible officials. The department would also try to avoid situations where an inadequate or delayed written response leads to the violation of the RTI Act, which is punishable by law. Therefore, the general experience is that the job is done without any further delay the moment a citizen files such a letter with the

[3] Note that the official would never present these objections in writing.

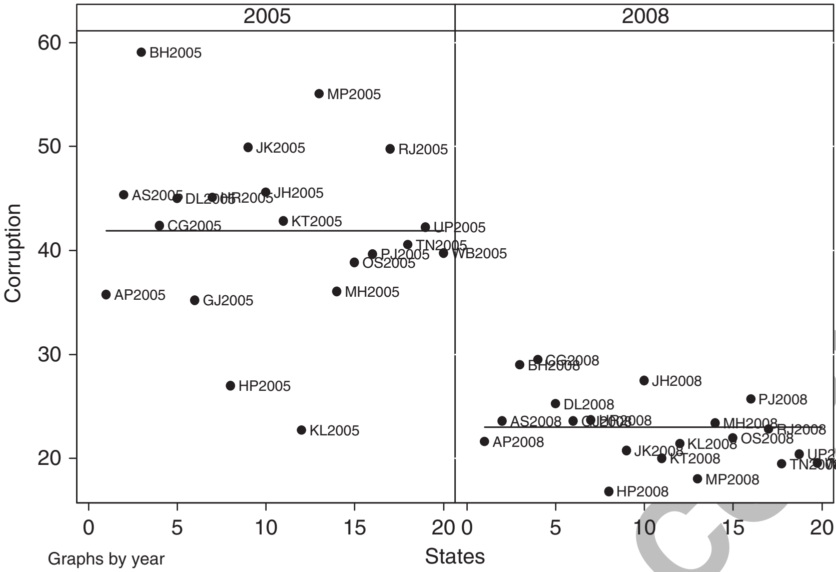

Figure 2: Corruption across states in 2005 and 2008.
Note: High value of the corruption variable indicates higher corruption. The line indicates period average across states. State codes are available in the Appendix section 'Data description'.

PIO. The officials are also aware of the power of RTI, and, therefore, they are much more cautious and less inclined to seek bribes.

By design, our dataset offers us the opportunity to test the effect of the law on corruption using two time series data points in our dataset, one before and the other after the law came into effect. Indeed, in Figure 2 we do notice that corruption declined significantly in 2008. However, this may also be due to some uncontrolled factors. The only way to find out is by controlling for additional factors that may be influencing corruption.

In this paper, using a panel dataset covering 20 Indian states and the periods 2005 and 2008 we estimate the causal effects of economic growth[4] and law on corruption. Since different states have experienced different growth patterns and different levels of corruption, India represents an ideal testing ground to examine the link between economic growth and corruption. To tackle endogeneity concerns we use rainfall as an instrument for economic growth. We notice that rainfall is a positive predictor of growth. This is in line

[4] Note that the Kolmogorov–Smirnov tests reported in Table 2 indicates that the distribution of corruption across states have changed over the two time periods. Forces such as economic growth may be driving these changes.

Table 2: Kolmogorov–Smirnov equality of distribution test over time periods 2005 and 2008

Variable	Kolmogorov–Smirnov test statistic	*p*-values
Corruption [c_{it}]	0.90	0.00
Corruption in banks [c_{it}^{BANKS}]	0.45	0.02
Corruption in land admin. [c_{it}^{LAND}]	0.80	0.00
Corruption in police [c_{it}^{POLICE}]	0.95	0.00
Corruption in education [c_{it}^{LAND}]	0.60	0.00
Corruption in water [c_{it}^{WATER}]	0.45	0.02
Corruption in PDS [c_{it}^{PDS}]	0.35	0.11
Corruption in electricity [c_{it}^{ELEC}]	0.60	0.00
Corruption in hospitals [c_{it}^{HOSP}]	0.70	0.00

Notes: The Kolmogorov–Smirnov non-parametric test is to test the hypothesis that distribution of corruption across states over the two time periods (2005 and 2008) are identical. In other words, the null hypothesis is H_0:$F_{2005}(c)$=$G_{2008}(c)$, where $F_{2005}(c)$ and $G_{2008}(c)$ are empirical distribution functions of corruption across states in 2005 and 2008, respectively. The test statistic is defined as $D = \max_{0<c<\infty} |F_{2005}(c) - G_{2008}(c)|$ and can be compared with Table 55 of *Biometrika* tables, Vol. 2. If the difference is large then it leads to rejection of the null hypothesis. Note that PDS stands for Public Distribution System.

with the view that rainfall contributes positively to economic growth. Rainfall perhaps also satisfies the exclusion restriction of an instrumental variable (IV) as it shows very low correlation with factors such as inequality and poverty through which, potentially, it could also affect corruption.[5] To capture the effect of law on corruption, we use a time dummy and control for other nationwide changes that may be affecting corruption. This is a valid strategy as the RTI came into effect after the completion of Transparency International's 2005 corruption survey. Our results indicate that economic growth reduces overall corruption experience as well as corruption in banking, land administration, education, electricity, and hospitals. It also reduces overall bribes and bribes in the above-mentioned sectors. However, growth has little impact on corruption perception. This is supportive of the view that corruption perceptions in developing economies are often biased upwards. In contrast, the RTI negatively impacts both corruption experience and corruption perception. Our basic result holds after controlling for state fixed effects and various additional covariates (eg literacy, Gini coefficient, poverty head count ratio, mining share of state GDP, primary sector share of state GDP, state government expenditure as a share of state GDP, newspaper circulation, and total number of telephone exchanges). It is also robust to the use of flood affected area, flood affected population, flood affected crop area,

[5] More on this in the section 'Empirical strategy and data'.

and total number of flood affected households as alternative instruments and outlier sensitivity tests.

We make the following four original contributions in this paper. First, by using a panel dataset on corruption across Indian states and a Limited Information Maximum Likelihood (LIML) IV estimation method we are able to estimate the causal effect of economic growth on corruption. Controlling for state fixed effects and additional covariates also allows us to tackle potential omitted variable bias. To the best of our knowledge, ours is the first panel data study of economic growth and corruption covering Indian states. Second, using a time dummy and exploiting the construction of our dataset we are able to estimate the corruption curbing effect of the RTI law in India. This is an important finding that has policy implications not just for India but also for other comparable developing economies suffering from endemic corruption. To the best of our knowledge, no other empirical study on corruption in India provides evidence of this nature. Third, using sector-wise disaggregated data we are able to estimate the causal effects of economic growth and law on corruption in banking, land administration, police, education, water supply, PDS, electricity, and hospitals. This in our view is an entirely new finding. Fourth, we are able to separately estimate the effects of economic growth and law on corruption experience and corruption perception and we do find that they are different. We notice that economic growth has very little influence on corruption perception. Our finding adds to a small but growing body of evidence on the difference between corruption perception and corruption experience (see Olken, 2009).

Our economic growth and corruption result is related to a large literature on corruption and development that follows from the seminal contribution by Mauro (1995).[6] However, note that our focus here is to estimate the causal effect of economic growth on corruption and not the other way around. Our law and corruption result is also related to a growing literature on democratization and corruption as it emphasizes the role of accountability. For example, Treisman (2000) shows that a long exposure to democracy reduces corruption. Bhattacharyya and Hodler (2010), using a game theoretic model and cross-national panel data, estimate a reduced-form econometric model and show that resource rent is bad for corruption although the effect is moderated by strong democratic institutions. In contrast, Fan *et al.* (2009) show that decentralized government may not increase accountability and reduce corruption if the government structures are complex. In a similar vein,

[6] Ades and Di Tella (1999), Rose-Ackerman (1999), Leite and Weidmann (1999), Dabla-Norris (2000) are other important contributions in this literature. Bardhan (1997) provides an excellent survey of the early contributions.

Olken (2007) also shows that top-down government audit works better than grassroots monitoring in Indonesia's village roads project. Therefore, our results contribute to a policy debate that is not only important for India but also for other comparable developing economies. The estimates are not directly comparable as there are significant differences in scale (micro-economic or macroeconomic), scope (national or international), and nature (theoretical, empirical, or experimental) of these studies.

Finally, our results are also related to a large literature on institutions and economic development (see Knack and Keefer, 1995; Hall and Jones, 1999; Acemoglu *et al.*, 2001; Rodrik *et al.*, 2004; Bhattacharyya, 2009). The major finding of this literature is that economic institutions (such as, property rights, contracts, regulation, and corruption) are one of the major drivers of long-run economic development. Besley and Burgess (2000, 2004) provide evidence that land property rights and labour market institutions have significant effects on economic performance across states in India. In this paper we estimate the magnitude of the relationship when causality runs in the opposite direction from economic growth to institutions.

The remainder of the paper is structured as follows: the next section discusses empirical strategy and the data. The section after that presents the empirical evidence and various robustness tests. The last section concludes.

EMPIRICAL STRATEGY AND DATA

We use a panel dataset covering 20 Indian states and the periods 2005 and 2008. Our basic specification uses corruption data for the years 2005 and 2008. Economic growth for the periods 2005 and 2008 are growth in GDP[7] over the periods 2004–2005 and 2007–2008, respectively. To estimate the causal effects of economic growth and law on corruption we use the following model:

$$c_{it} = \alpha_i + \delta\beta_t + \gamma_1\hat{y}_{it} + \mathbf{X}_{\mathbf{it}}^{'}\mathbf{\Lambda} + \varepsilon_{it} \tag{1}$$

where c_{it} is a measure of corruption in state i at year t, α_i is a state dummy variable covering 20 Indian states to control for state fixed effects, β_t is a dummy variable that takes the value 1 for the year 2008 to estimate the impact of the introduction of the RTI Act (on October 12, 2005), $\hat{y}_{it}$ is economic growth in state i over the period $t-1$ to t, and $\mathbf{X}_{\mathbf{it}}$ is a vector of other control variables.

[7] Note that we also use GDP per capita growth rate in Table 3 and our results are robust.

Table 3: Economic growth, law, and corruption

	Dependent variable: Corruption [c_{it}]			
	(1)	(2)	(3)	(4)
Panel A				
	OLS estimates		LIML Fuller IV estimates	
Economic growth [$\hat{y}_{it}$]	−0.33***		−0.43***	
	(0.12)		(0.14)	
Year 2008 dummy	−18.24***	−17.08***	−18.48***	−18.83***
	(3.08)	(2.59)	(1.49)	(1.92)
Per capita GDP growth		−0.23**		−0.39**
		(0.11)		(0.21)
Endogeneity test (*p*-value)			0.07	0.06
Controls:	State dummies			
Instruments			Log rainfall [ln $RAIN_{it-1}$]	
States	20	20	20	20
Observations	40	40	40	40
Adjusted R^2	0.89	0.88		
Panel B: First stage estimates				
	Economic growth [$\hat{y}_{it}$]		Per capita GDP growth	
Log rainfall [ln $RAIN_{it-1}$]	12.2*		14.7*	
	(6.55)		(9.30)	
F statistic	12.4		13.14	
Stock–Yogo critical value	24.09		23.81	
Partial R^2 on instruments	0.009		0.018	
Controls:	State dummies, Year 2008 dummy			
States	20		20	
Observations	40		40	
Adjusted R^2	0.76		0.57	

Notes: ***, **, and * indicate significance level at 1%, 5%, and 10%, respectively, against a two-sided alternative. Figures in the parentheses are cluster standard errors at the state level and they are robust to arbitrary heteroskedasticity and arbitrary intra-group correlation. All regressions are carried out with an intercept. Sample years are 2005 and 2008. Fuller's modified LIML estimator with α=1 (correction parameter proposed by Hausman *et al.*, 2005) is used in Panel A, which is robust to weak instruments. Endogeneity test for one or more endogenous regressors *p*-values are reported. The null hypothesis is that the specified endogenous variables can actually be treated as exogenous. Under the null the test statistic follows χ^2-distribution with degrees of freedom equal to the number of regressors tested. Note that Sargan overidentification test is not reported for columns 3 and 4 in Panel A as we have an exactly identified system. Stock–Yogo critical value are based on LIML size and significance level of 5%. An *F*-statistic below the level of Stock–Yogo critical value would indicate that the instruments are weak. Partial R^2 on excluded instruments are also reported, which measures instrument relevance.

A high value of c_{it} implies a high level of corruption. The motivation behind including state fixed effects is to control for time invariant state-specific fixed factors such as language, culture, and ethnic fractionalization.

The main variables of interest are $\hat{y}_{it}$ and the time dummy variable β_t. Therefore γ_1 and δ are our focus parameters. In theory, we would expect γ_1 to be significantly negative as faster growing states are able to use additional resources to curb corruption. The coefficient estimate δ is expected to capture the effect of the RTI Act. This is equivalent to a before and after estimation strategy in panel data econometrics. Ideally one would like to compare the effect of RTI on corruption before and afterwards in the areas affected by the law, and then compare this to the effects before and afterwards in the areas not affected by the law. Unfortunately this is not feasible here as the RTI law came into effect nationally. In other words, there is no comparison group here since the law was introduced at the same time in all locations. Nevertheless, the strategy implemented here is credible at the macro level.

To illustrate the before and after strategy, let c_{1it} be the corruption outcome in state i at time t when the RTI Act is in effect. Similarly, let c_{2it-1} be the corruption outcome in state i at time $t-1$ when the RTI Act is not in effect. Note that these are potential outcomes, and in practice we only get to observe one or the other. One can express the above as:

$$\begin{aligned} &E[c_{1it}|i, t = 1, \hat{y}_{it} = \bar{y}, \mathbf{X}'_{\mathbf{it}} = \bar{\mathbf{X}}] = \alpha_i + \delta \quad \text{and} \\ &E[c_{2it-1}|i, t-1 = 0, \hat{y}_{it} = \bar{y}, \mathbf{X}'_{\mathbf{it}} = \bar{\mathbf{X}}] = \alpha_i \end{aligned} \tag{2}$$

Given that $E(\varepsilon_{it}|i, t) = 0$. The population before and after estimates yields the causal effect of the RTI Act δ as follows:

$$E[c_{1it}|i, t = 1, \hat{y}_{it} = \bar{y}, \mathbf{X}'_{\mathbf{it}} = \bar{\mathbf{X}}] - E[c_{2it-1}|i, t-1 = 0, \hat{y}_{it} = \bar{y}, \mathbf{X}'_{\mathbf{it}} = \bar{\mathbf{X}}] = \delta \tag{3}$$

This can be estimated by using the sample analog of the population means. If the RTI law is effective in curbing corruption then we would expect δ to be negative.

Data on corruption are from the Transparency International's India Corruption Study 2005 and 2008. The study was jointly conducted by Transparency International India and the Centre for Media Studies both located in New Delhi. The survey for the 2005 report was conducted between December 2004 and January 2005 and the survey for the 2008 report was conducted between November 2007 and January 2008. The survey asks respondents whether (i) they have direct experience of bribing, (ii) they have used a middleman, (iii) they perceive a department to be corrupt, and (iv) they perceive corruption has increased over time.[8] These questions are asked

[8] Note that the survey asks some additional questions. However, they are not common over the two time periods in our study. Therefore we are not including them here.

to on average 750 respondents from each of the 20 states. Respondents are selected using a random sampling technique covering both rural and urban areas. In aggregate the 2005 survey interviews 14,405 respondents spread over 151 cities and 306 villages of the 20 states. In contrast, the 2008 survey covers 22,728 randomly selected Below Poverty Line (BPL) respondents across the country. One could argue that this brings in issues of measurement error that will bias our estimates downwards. This is formally known as the attenuation bias, which is driven by measurement error. So what we estimate in the presence of measurement error is in fact less in magnitude than the true effect. Furthermore, if the measurement error follows all classical assumptions (in other words, random) then our estimates will remain unaffected. Nevertheless, measurement error problem can be mitigated using the IV strategy, and we remedy this problem using rainfall as an instrument. Rainfall is geography-based and therefore exogenous or uncorrelated to the measurement error. Hence rainfall can serve as a valid instrument to remedy measurement-error-driven attenuation bias. The Appendix section 'Measurement error and instrumental variable estimation' shows algebraically how the IV strategy could potentially remedy the measurement error problem.

Our aggregate measure of corruption c_{it} is computed in two steps. First, an average is computed of the percentage of respondents answering yes to the questions that they have direct experience of bribing, using a middleman, perception that a department is corrupt, and perception that corruption increased over time for eight different sectors: banking, land administration, police, education, water, PDS, electricity, and hospitals.[9] Second, these averages are also averaged over all the eight sectors to generate one observation per state and per time period. Ideally, one should weigh the sectors with their respective usages. But in the absence of reliable usage statistics at the state level, we compute averages with equal weights. This may not be a cause for concern as services from all of these sectors are widely used by citizens. Note that the sector-level disaggregated data are utilized in Table 4, and Table 5 treats corruption perception and corruption experience separately. Corruption experience measure is the average of the questions on 'direct experience of bribing' and 'using a middleman'. Corruption perception measure is the average of the questions on 'perception that a department is corrupt' and 'perception that corruption increased over time'.

The state of Bihar turns out to be the most corrupt in our sample with 59% of respondents reporting corruption in 2005. In contrast Himachal Pradesh is the least corrupt with only 17% of the respondents reporting

[9] Note that the India Corruption Study only reports these macro percentages and the underlying micro data is not reported.

Table 4: Economic growth, law, and corruption in different sectors

	Corruption in banks $[c_{it}^{BANKS}]$	Corruption in land admin. $[c_{it}^{LAND}]$	Corruption in police $[c_{it}^{POLICE}]$	Corruption in education $[c_{it}^{EDUC}]$	Corruption in water $[c_{it}^{WATER}]$	Corruption in PDS $[c_{it}^{PDS}]$	Corruption in electricity $[c_{it}^{ELEC}]$	Corruption in hospitals $[c_{it}^{HOSP}]$
	LIML Fuller IV estimates							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Economic growth [$\hat{y}_{it}$]	−0.46**	−0.96***	0.33	−0.60***	−0.85	0.11	−0.76**	−0.85***
	(0.19)	(0.20)	(0.28)	(0.13)	(0.60)	(0.44)	(0.31)	(0.18)
Year 2008 dummy	−9.43***	−17.18***	−20.38***	−9.03***	−7.91***	−6.15*	−11.55***	−12.78***
	(3.13)	(3.14)	(2.71)	(1.83)	(2.86)	(3.33)	(2.48)	(2.44)
Endogeneity test (*p*-value)	0.06	0.05	0.07	0.06	0.06	0.06	0.08	0.06
Controls:	State dummies							
Instruments	Log Rainfall [ln $RAIN_{it-1}$]							
States	20	20	20	20	20	20	20	20
Observations	40	40	39	40	39	40	40	40

Notes: ***, **, and * indicate significance level at 1%, 5%, and 10%, respectively, against a two-sided alternative. Figures in the parentheses are cluster standard errors and they are robust to arbitrary heteroskedasticity and arbitrary intra-group correlation. All regressions are carried out with an intercept. Sample years are 2005 and 2008. Fuller's modified LIML estimator with α=1 (correction parameter proposed by Hausman *et al*., 2005) is used, which is robust to weak instruments. Endogeneity test for one or more endogenous regressors *p*-values are reported. The null hypothesis is that the specified endogenous variables can actually be treated as exogenous. Under the null the test statistic follows χ^2-distribution with degrees of freedom equal to the number of regressors tested. Note that Sargan overidentification test is not reported as we have an exactly identified system.

Table 5: Effect of economic growth and law on corruption experience and corruption perception

	Corruption experience overall	Corruption experience in banks	Corruption experience in land admin.	Corruption experience in police	Corruption experience in education	Corruption experience in water	Corruption experience in PDS	Corruption experience in electricity	Corruption experience in hospitals
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: LIML Fuller IV estimates with corruption experience									
Economic growth [$\hat{y}_{it}$]	−0.92***	−0.77***	−1.66***	−0.19	−0.87***	−0.80	−0.13	−0.97***	−1.79***
	(0.21)	(0.25)	(0.59)	(0.58)	(0.09)	(0.87)	(0.37)	(0.29)	(0.34)
Year 2008 dummy	−17.09***	−11.55***	−29.25***	−12.09***	−7.55***	−7.65**	−10.39***	−11.04***	−7.22***
	(2.05)	(2.19)	(4.99)	(4.49)	(1.47)	(3.81)	(3.31)	(1.93)	(2.74)
Endogeneity test (*p*-value)	0.06	0.06	0.08	0.05	0.04	0.05	0.06	0.06	0.06
Controls:					State dummies				
Instruments					Log rainfall [ln $RAIN_{it-1}$]				
States	20	20	20	20	20	20	20	20	20
Observations	40	40	40	39	40	39	40	40	40
	Corruption perception overall	Corruption perception in banks	Corruption perception in land admin.	Corruption perception in police	Corruption perception in education	Corruption perception in water	Corruption perception in PDS	Corruption perception in electricity	Corruption perception in hospitals
Panel B: LIML Fuller IV estimates with corruption perception									
Economic growth [$\hat{y}_{it}$]	−0.21	−0.11	−0.83	0.72*	−0.64*	−0.84	0.05	−0.62	0.22
	(0.36)	(0.45)	(0.62)	(0.37)	(0.34)	(0.96)	(0.65)	(0.54)	(0.41)
Year 2008 dummy	−15.35***	−14.42**	−12.17***	−14.27***	−14.54***	−12.47***	−6.67	−19.14***	−18.12***
	(2.86)	(5.95)	(4.11)	(3.69)	(2.77)	(4.73)	(4.44)	(3.83)	(2.59)
Endogeneity test (*p*-value)	0.06	0.06	0.07	0.05	0.03	0.06	0.05	0.06	0.06
Controls:					State dummies				
Instruments					Log rainfall [ln $RAIN_{it-1}$]				
States	20	20	20	20	20	20	20	20	20
Observations	40	40	40	39	40	39	40	40	40

Notes: ***, **, and * indicate significance level at 1%, 5%, and 10%, respectively, against a two-sided alternative. Figures in the parentheses are cluster standard errors and they are robust to arbitrary heteroskedasticity and arbitrary intra-group correlation. All regressions are carried out with an intercept. Sample years are 2005 and 2008. Fuller's modified LIML estimator with α=1 (correction parameter proposed by Hausman *et al.*, 2005) is used, which is robust to weak instruments. Endogeneity test for one or more endogenous regressors *p*-values are reported. The null hypothesis is that the specified endogenous variables can actually be treated as exogenous. Under the null the test statistic follows χ^2-distribution with degrees of freedom equal to the number of regressors tested. Note that Sargan overidentification test is not reported as we have an exactly identified system.

corruption in 2008. It appears that police, land administration, and PDS are among the most corrupt sectors in our dataset. Kerala and Himachal Pradesh come out to be the least corrupt states in most of the cases. In contrast Bihar, Jammu and Kashmir, Madhya Pradesh, and Rajasthan register high levels of corruption.

Economic growth $\hat{y}_{it}$ is defined as the growth in real GDP of the states over the periods 2004–2005 and 2007–2008, respectively. We use real GDP as our preferred measure instead of real GDP per capita to compute growth rates because aggregate growth of the economy (modernization effect) is more likely to have an impact on corruption at the macro level than per capita growth. Nevertheless, we also use per capita GDP growth to estimate the model and our results are robust. Real GDP growth data are from the Planning Commission. Our growth variable varies between −4.2% in Bihar in 2005 and almost 17% in Chhattisgarh in 2005.

As economic growth here is arguably endogenous, one key question is the issue of reverse causation. Corruption, as argued by many including Mauro (1995), may dampen growth through the investment channel. In that case, a simple OLS estimate of our model would be biased. In order to estimate the causal effect of economic growth on corruption we need to implement the IV estimation strategy. In particular, we need to identify an exogenous variable that is correlated with economic growth but uncorrelated with the error term ε_{it} in the model, that is, this exogenous variable would affect corruption exclusively through the economic growth channel. This is commonly known as the exclusion restriction. Indeed, finding such a variable is a challenge in itself. But we are fortunate to have log rainfall ($\ln RAIN_{it-1}$) from the Compendium of Environmental Statistics published by the Central Statistical Organization. We notice that $\ln RAIN_{it-1}$ is positively related to economic growth and the relationship is statistically significant. This is in line with the view that rainfall positively contributes to economic growth. Furthermore, $\ln RAIN_{it-1}$ is geography-based and therefore is exogenous. However, rainfall may affect corruption through channels other than economic growth. Poverty and inequality are such examples. Rainfall may lead to reduction in poverty, which may in turn lead to a reduction in corruption. Better rainfall and better agriculture growth may also increase inequality leading to an increase in corruption. In such a situation the rainfall instrument may not satisfy the exclusion restriction. To eliminate such possibility, we check the correlation between the rainfall instrument and poverty and inequality. It turns out to be 0.17 and 0.38, respectively, which suggests it is unlikely that rainfall would affect corruption through the poverty and inequality channels. Therefore, it is safe to conclude that $\ln RAIN_{it-1}$ can serve as a valid instrument. However, if the relationship between ln $RAIN_{it-1}$ and $\hat{y}_{it}$ is not strong enough then it may lead to the weak instruments problem. Staiger and Stock (1997) and Stock and Yogo (2005) show that if the instruments in a regression are only weakly correlated with the suspected endogenous variables then the estimates are likely to be biased. Instruments are considered to be weak if the first stage F-statistic is less than Stock–Yogo critical value. The LIML Fuller version of the IV method is robust to weak instruments. We implement the LIML method to estimate our model. Moreover, we operate with a relatively small sample of 40 observations and the LIML estimates are robust to small samples. Therefore, the risk of a significantly large bias due to weak instruments is minor.

Finally, another potential concern is about the power of the diagnostic tests with limited degrees of freedom. LIML estimates adopted here are best suited for this purpose as they have robust and powerful small sample properties. Nevertheless, we also perform the following two tests to be certain about the validity of our conclusions. First, we adopt Hendry *et al.*'s (2004) least square dummy variables approach and our results are robust. This method can be implemented using the following two steps. The first step is to estimate the model using LIML and identify all the statistically insignificant state dummy variables. Then the second step is to re-estimate the model using LIML but without the statistically insignificant state dummies. The advantage is that this significantly improves the power of the tests. Second, we estimate the model without any state dummies and our results are robust. These results are reported in columns 9 and 10 of Table 7.

The time dummy is used to capture the effect of the RTI Act. One can certainly dispute whether our time dummy is solely picking up the effect of RTI and Citizens' Charter. It is possible that other nationwide changes introduced around this time are also affecting corruption. In that case the estimate on the time dummy is also picking up the effects of factors other than the RTI. Even though plausible, it is hard to identify significant national policy changes during this time other than the RTI that may affect corruption. Nevertheless, to tackle this issue we also control for literacy, Gini coefficient, poverty head count ratio, mining share of GDP, primary sector share of GDP, state government expenditure, newspaper circulation, and total number of telephone exchanges as additional control variables. Therefore it is perhaps safe to say that δ is indeed capturing the effects of RTI.

Detailed definitions and sources of all variables are available in Appendix section 'Data description'. Table 1 reports descriptive statistics of the major variables used in the study. The Appendix section 'Sample and state codes' provides a list of 20 states covered in the study and presents a map of Indian states.

EMPIRICAL EVIDENCE

Table 2 reports Kolmogorov–Smirnov test results for the equality of distributions of corruption over the time periods 2005 and 2008. The test shows that the distribution of corruption across states has changed over the two time periods. This may be driven by the variation in economic growth across states. In Table 3 we try to ascertain this by estimating equation 1 using OLS and LIML Fuller IV methods. Column 1 reports the OLS estimates and column 3 presents estimates of the model using ln $RAIN_{it-1}$ as an instrument for economic growth. Our suspicion that economic growth can be endogenous is supported by the endogeneity test reported at the bottom of column 3. We notice that economic growth has a negative impact on corruption. *Ceteris paribus*, one sample standard deviation (4.1% points) increase in economic growth in an average state would reduce corruption by 1.8% points. In other words, our model predicts that an increase in the growth rate of Bihar from −4.2% in 2005 to 16% in 2008 would reduce corruption from 59% in 2005 to 50.3% in 2008. According to our dataset, Bihar's actual corruption in 2008 is 29%. Therefore, the estimated coefficient on economic growth explains 29% of the actual decline in corruption in Bihar over the period 2005–2008.

The coefficient on the year 2008 dummy captures the effect of RTI. Our estimates suggest that RTI has a negative impact on corruption and the effect is statistically significant. In particular, *ceteris paribus*, the RTI Act reduces corruption in an average state by 18.5% points. To put this into perspective, the RTI Act explains approximately 62% of the actual decline in corruption in Bihar over the period 2005–2008.[10] This is indeed a large effect.

Note that IV coefficient estimates are typically larger than the OLS estimates. This is not surprising given that IV estimates are correcting for the measurement-error-induced attenuation bias in OLS.

In column 4 we use per capita GDP growth instead of aggregate GDP growth and our result remains unaffected. The evidence here supports the hypothesis that rapidly growing per capita income also increases the personal opportunity costs of corruption. Note that we also estimate the model using 5-year average growth rates instead of economic growth over the periods 2004–2005 and 2007–2008. Our results are robust to this test. Results are not reported here but are available upon request. Column 2 reports the OLS estimate of this model.

[10] The model predicts that corruption in Bihar should have declined by 18.5% points due to the RTI Act. However, the actual decline is 30% points. Therefore, the predicted decline is 62% of the actual.

How good is our ln $RAIN_{it-1}$ instrument? Panel B in Table 3 shows that it is positively correlated with economic growth. Therefore it can serve as an instrument provided it satisfies the exclusion restriction. In other words, rainfall affects corruption exclusively through the economic growth channel. However, rainfall may affect corruption through channels other than economic growth. Poverty and inequality are such candidates. Rainfall may lead to reduction in poverty, which may in turn lead to a reduction in corruption. Better rainfall and better agriculture growth may also increase inequality leading to an increase in corruption. In such situation, the exclusion restriction would be violated.

In Table 4 we ask whether the effect of economic growth and law on corruption is uniform across all sectors of the economy. In particular we look at corruption in banking, land administration, police, education, water supply, PDS, electricity, and hospitals. Indeed there are more sectors in an economy that may have chronic corruption problem, and we admit that our list is far from being comprehensive. However, it should be noted that our study is the first attempt to look at corruption at a disaggregated level in India using panel data and we are constrained by data availability. The results indicate that the RTI Act had an impact on all sectors examined in this study. However, the magnitude of the predicted decline varies from a 20.4% points in policing to 6.2% points in the PDS. In contrast, the effect of economic growth is far from being uniform. Banking, land administration, education, electricity, and hospitals register a statistically significant negative effect of economic growth on corruption. However, the effect is insignificant in case of policing, water supply, and PDS.

In Table 5 we check whether there is a difference between actual corruption experience and corruption perception. Indeed, we find that the effect of economic growth on corruption is not uniform across actual experience and perception. Panel A reports estimates with actual corruption experience. Note that corruption experience here is the average of answers to the questions on 'direct experience of bribing' and 'using influence of a middleman'. In addition to affecting overall corruption experience, economic growth appears to reduce corruption experiences in banking, land administration, education, electricity, and hospitals. The effects on police, water supply, and the PDS is statistically insignificant. The observed pattern is very similar to Table 4. This suggests that our corruption results reported in Tables 3 and 4 are driven by actual corruption experiences. Panel B reports estimates with corruption perception. Note that corruption perception here is the average of answers to the questions on 'perception that a department is corrupt' and 'perception that corruption has increased'. We notice that economic growth has little effect on corruption perception and, in case of policing, it appears to have increased corruption perception.[11] This is in line with the view that perpetual pessimism with regards to government services tends to shape corruption perception in developing economies, and any impact that economic growth may have on actual corruption is often overlooked. Our result is broadly in line with the findings of Olken (2009) who also reports differences in corruption perception and corruption experience in Indonesia, another developing economy.

The effect of RTI on corruption experience and corruption perception is somewhat uniform. However, the magnitude of the effect varies across sectors. We notice that the effect of RTI on corruption experience is greater than its effect on corruption perception in case of overall corruption, land administration, and PDS. In contrast, the reverse is observed in case of banking, police, education, water supply, electricity, and hospitals.

In Table 6 we dissect corruption experience even further and examine the effect of growth on bribes and the usage of middlemen separately. The results are similar to Table 5, Panel A. In addition to affecting overall bribes, economic growth appears to reduce bribes in banking, land administration, education, electricity, and hospitals. However, the effects on police, water supply, and PDS are statistically insignificant. The time dummy remains significant throughout, highlighting the importance of RTI. The results are similar for middlemen usage.

In Table 7 we add additional covariates into our specification to address the issue of omitted variables. In column 1 we add literacy as an additional control variable. The rationale is that literate citizens are relatively more empowered to fight corruption. Our result survives. Poverty and inequality may also increase corruption. To check whether this has any effect we add Gini coefficient and poverty head count ratio as additional controls in columns 2 and 3. Our result remains unaffected. Natural resources in general and resource rent in particular may also increase corruption (see Ades and Di Tella, 1999; Treisman, 2000; Isham *et al.*, 2005; Bhattacharyya and Hodler, 2010). To check we add mining share of GDP and primary sector share of GDP in columns 4 and 5 and our results are robust. High levels of government expenditure may increase corruption as corrupt officials now have access to more resources to usurp. It can also work in the opposite direction with the government now able to engage more resources into auditing. Indeed we do notice evidence in support of the latter in column 6 with state government expenditure having a significant negative impact on corruption. This is in line with Olken (2007) who shows that government audit reduces corruption in

[11] According to our estimates, economic growth reduced corruption perception only in education.

Indonesia. Nevertheless, more importantly our economic growth and law results remain unaffected. In column 7 we test whether controlling for the effect of media would alter our result. Media and an active civil society may reduce corruption. We try to capture this effect using newspaper circulation. Our main result survives. Column 8 tackles the view that telecommunication revolution in India may have triggered this decline in corruption by eliminating the middleman and reducing discretionary power of corrupt officials. To capture this effect we use number of telephone exchanges as a control variable, and our results survive.

Note that we perform two further tests. First, we test whether our results are driven by influential observations. We identify influential observations using Cook's distance, DFITS, and Welsch distance formula and eliminate them from the sample. Our result remains unaffected. Second, we estimate the model using flood affected area, flood affected population, flood affected crop area, and total number of flood affected households as alternative instruments. Our results survive this test. Furthermore, note that the results remain unaffected if these instruments are used in conjunction with rainfall and the Sargan tests are satisfied. These results are not reported but are available upon request.

Overall these empirical findings support our prediction that both economic growth and RTI have negative impacts on corruption. However, the effect of the RTI Act is more uniform than the effect of economic growth.

CONCLUDING REMARKS

We study the causal impact of economic growth and law on corruption. Using a panel dataset covering 20 Indian states and the years 2005 and 2008 we are able to estimate the causal effects of economic growth and law on corruption. To tackle endogeneity concerns we use rainfall as an instrument for economic growth. Rainfall is a positive predictor of growth which is in line with the view that rainfall contributes positively to economic growth. It also affects corruption through the economic growth channel reasonably exclusively. To capture the effect of law on corruption we use a time dummy and control for other nationwide changes, which may be affecting corruption. Our results indicate that economic growth reduces overall corruption as well as corruption in banking, land administration, education, electricity, and hospitals. However, growth has little impact on corruption perception. In contrast the RTI negatively impacts both corruption experience and corruption perception. Our basic result holds after controlling for state fixed effects and various additional covariates, literacy, Gini coefficient, poverty

Table 6: Effect of economic growth and law on bribes and middleman usage

	Bribes overall	Bribes in banks	Bribes in land admin.	Bribes in police	Bribes in education	Bribes in water	Bribes in PDS	Bribes in electricity	Bribes in hospitals
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: LIML Fuller IV estimates with bribes									
Economic growth [$\hat{y}_{it}$]	−0.93***	−0.87***	−1.26***	−0.14	−0.83***	−0.69	−0.11	−1.17***	−1.69***
	(0.26)	(0.21)	(0.39)	(0.48)	(0.09)	(0.80)	(0.37)	(0.20)	(0.31)
Year 2008 dummy	−17.34***	−11.31***	−27.36***	−13.62***	−6.21***	−7.64**	−10.39***	−11.68***	−7.14***
	(3.65)	(2.20)	(4.65)	(4.16)	(1.92)	(3.86)	(3.32)	(1.76)	(2.05)
Endogeneity test (p-value)	0.06	0.06	0.09	0.06	0.04	0.05	0.06	0.07	0.06
Controls:					State dummies				
Instruments					Log rainfall [ln $RAIN_{it-1}$]				
States	20	20	20	20	20	20	20	20	20
Observations	40	40	40	39	40	39	40	40	40
	Middleman overall	Middleman in banks	Middleman in land admin.	Middleman in police	Middleman in education	Middleman in water	Middleman in PDS	Middleman in electricity	Middleman in hospitals
Panel B: LIML Fuller IV estimates with middlemen usage									
Economic growth [$\hat{y}_{it}$]	−0.71**	−0.62**	−0.98**	−0.13	−0.71***	−0.49	−0.09	−0.97***	−1.80***
	(0.32)	(0.24)	(0.32)	(0.47)	(0.14)	(0.62)	(0.28)	(0.26)	(0.38)
Year 2008 dummy	−18.48***	−11.29***	−21.13***	−12.89***	−4.68***	−6.62**	−10.86***	−11.09***	−7.48***
	(2.13)	(2.49)	(4.32)	(4.79)	(1.91)	(3.18)	(3.76)	(1.96)	(2.65)
Endogeneity test (p-value)	0.06	0.06	0.07	0.06	0.04	0.05	0.06	0.06	0.06
Controls:					State dummies				
Instruments					Log rainfall [ln $RAIN_{it-1}$]				
States	20	20	20	20	20	20	20	20	20
Observations	40	40	40	39	40	39	40	40	40

Notes: ***, **, and * indicate significance level at 1%, 5%, and 10%, respectively, against a two-sided alternative. Figures in the parentheses are cluster standard errors and they are robust to arbitrary heteroskedasticity and arbitrary intra-group correlation. All regressions are carried out with an intercept. Sample years are 2005 and 2008. Fuller's modified LIML estimator with α=1 (correction parameter proposed by Hausman *et al.*, 2005) is used, which is robust to weak instruments. Endogeneity test for one or more endogenous regressors p-values are reported. The null hypothesis is that the specified endogenous variables can actually be treated as exogenous. Under the null the test statistic follows χ^2-distribution with degrees of freedom equal to the number of regressors tested. Note that Sargan overidentification test is not reported as we have an exactly identified system.

Table 7: Economic growth, law, and corruption: Robustness with additional covariates

	Dependent variable: Corruption [c_{it}]									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	LIML Fuller IV estimates									
Economic growth [$\hat{y}_{it}$]	−0.34***	−0.39***	−0.44***	−0.44***	−0.48**	−0.17***	−0.76***	−0.64***	−0.47***	−1.22**
	(0.05)	(0.12)	(0.13)	(0.16)	(0.22)	(0.02)	(0.06)	(0.21)	(0.16)	(0.67)
Year 2008 dummy	−19.12***	−19.58***	−18.62***	−18.83***	−18.06***	−15.51***	−17.23***	−19.91***	−18.21***	−18.41***
	(2.02)	(1.75)	(1.81)	(2.27)	(2.24)	(2.18)	(1.70)	(3.19)	(1.94)	(1.94)
Endogeneity test (*p*-value)	0.06	0.07	0.06	0.06	0.06	0.06	0.06	0.07	0.06	0.07
Controls:	State dummies								State Dummies without AP, TN, WB	—
Additional controls:	Literacy	Gini coefficient	Poverty head count ratio	Mining share of GDP	Primary sector share of GDP	State government expenditure***(-)	Newspaper circulation	Telephone exchange	—	—
Instruments	Log Rainfall [ln $RAIN_{it-1}$]									
States	18	20	20	20	20	19	18	14	20	20
Observations	36	40	40	40	40	38	36	28	40	40

Notes: ***, **, and * indicate significance level at 1%, 5%, and 10%, respectively, against a two-sided alternative. Figures in the parentheses are cluster standard errors and they are robust to arbitrary heteroskedasticity and arbitrary intra-group correlation. All regressions are carried out with an intercept. Sample years are 2005 and 2008. Fuller's modified LIML estimator with α=1 (correction parameter proposed by Hausman *et al.*, 2005) is used, which is robust to weak instruments. Endogeneity test for one or more endogenous regressors *p*-values are reported. The null hypothesis is that the specified endogenous variables can actually be treated as exogenous. Under the null the test statistic follows χ^2-distribution with degrees of freedom equal to the number of regressors tested. Note that Sargan overidentification test is not reported as we have an exactly identified system. Also note that columns 9 and 10 report the Hendry *et al.* (2004) procedure and the estimates without state dummies. These procedures are described in the section 'Empirical strategy and data'.

head count ratio, mining share of state GDP, primary sector share of state GDP, state government expenditure as a share of state GDP, newspaper circulation, and number of telephone exchanges. It is also robust to the use of alternative instruments and outlier sensitivity tests.

Our results have important policy implications not just for India but also for other comparable developing economies. Our findings imply that economic forces have an important role in reducing corruption. Therefore, macro policies to promote economic growth not only improve overall living standards, but they also enhance the quality of public goods by reducing corruption. This perhaps works through the following channels. First, it provides the government with additional resources to fight corruption. Second, it also reduces the incentives for corruption at the micro level by raising the opportunity cost. More micro level research is certainly called for to find out whether the data supports these conjectures.

Legislation such as the RTI Act in India is also important in curbing corruption. On the one hand it empowers citizens' and breaks the information monopoly of public officials. Therefore, it prevents corrupt public officials from misusing information to advance their own interest. On the other hand, it provides the government with more power and public support for conducting top down audit of corrupt departments. There is evidence that the latter works effectively in a developing economy environment (Olken, 2007).

Finally, more caution is required in the measurement of corruption. Our results indicate that there is a fair bit of difference between actual corruption experience and corruption perception in developing economies. Therefore overreliance on one or the other may be counterproductive. We do not stand alone on this, as other studies also indicate that perception and actual corruption tends to vary significantly (Olken, 2009). Measuring corruption appropriately in our view is crucial in furthering our understanding of corruption.

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APPENDIX

Data description

Corruption [c_{it}]: Corruption is computed using a two-step procedure. First, an average is computed of the percentage of respondents answering yes to the questions that they have direct experience of bribing, using a middleman, perception that a department is corrupt, and perception that corruption increased over time for eight different sectors: banking, land administration, police, education, water, Public Distribution System (PDS), electricity, and hospitals. Second, these averages are also averaged over all the eight sectors to generate one observation per state and per time period. Higher value of the corruption measure implies higher corruption.
Source: India Corruption Study 2005 and 2008, Transparency International.

Corruption in Banks [c_{it}^{BANKS}]: Corruption computed in the same fashion as c_{it} but only for the banking sector.
Source: India Corruption Study 2005 and 2008, Transparency International.

Corruption in Land Administration [c_{it}^{LAND}]: Corruption computed in the same fashion as c_{it} but only for the land administration sector.
Source: India Corruption Study 2005 and 2008, Transparency International.

Corruption in Police [c_{it}^{POLICE}]: Corruption computed in the same fashion as c_{it} but only for police.
Source: India Corruption Study 2005 and 2008, Transparency International.

Corruption in Education [c_{it}^{EDUC}]: Corruption computed in the same fashion as c_{it} but only for education sector.
Source: India Corruption Study 2005 and 2008, Transparency International.

Corruption in Water [c_{it}^{WATER}]: Corruption computed in the same fashion as c_{it} but only for the water supply sector.
Source: India Corruption Study 2005 and 2008, Transparency International.

Corruption in PDS [c_{it}^{PDS}]: Corruption computed in the same fashion as c_{it} but only for the public distribution system.
Source: India Corruption Study 2005 and 2008, Transparency International.

Corruption in Electricity [c_{it}^{ELEC}]: Corruption computed in the same fashion as c_{it} but only for the electricity sector.
Source: India Corruption Study 2005 and 2008, Transparency International.

Corruption in Hospitals [c_{it}^{HOSP}]: Corruption computed in the same fashion as c_{it} but only for hospitals.
Source: India Corruption Study 2005 and 2008, Transparency International.

Corruption Experience Measures: Corruption experience measures are the average of answers to the questions on 'direct experience of bribing' and 'using influence of a middleman'.
Source: India Corruption Study 2005 and 2008, Transparency International.

Corruption Perception Measures: Corruption perception measures are the average of answers to the questions on 'perception that a department is corrupt' and 'perception that corruption has increased'.
Source: India Corruption Study 2005 and 2008, Transparency International.

Economic Growth [$\hat{y}_{it}$]: Real growth rate in state GDP measured in 2009 constant prices.
Source: Planning Commission, Government of India.

Log Rainfall [$\ln RAIN_{it-1}$]: Log of rainfall across states measured in millimeters.
Source: Compendium of Environmental Statistics, Central Statistical Organisation, Ministry of Statistics and Programme Implementation.

Flood Area: Total area affected by flood in 1994 and 1996 measured in millions of hectares.
Source: Central Water Commission, Government of India.

Flood Population: Total population affected by flood in 1994 and 1996 measured in millions.
Source: Central Water Commission, Government of India.

Flood Crop Area: Total crop area affected by flood in 1994 and 1996 measured in millions of hectares.
Source: Central Water Commission, Government of India.

Flood Household: Total number of households affected by flood in 1994 and 1996 measured in millions of hectares.
Source: Central Water Commission, Government of India.

Literacy: Literacy rate for 2002 and 2005.
Source: Selected Socioeconomic Statistics India 2006, Central Statistical Organization, Table 3.3.

Gini Coefficient: Gini coefficient urban for the periods 1999–2000 and 2004–2005.
Source: Planning Commission.

Poverty Head Count Ratio: Percentage of population below poverty line (rural and urban combined).
Source: Planning Commission.

Mining Share of GDP: Mining sector share of state GDP.
Source: Handbook of Statistics on the Indian Economy, Reserve Bank of India.

Primary Sector Share of GDP: Primary sector share of state GDP.
Source: Handbook of Statistics on the Indian Economy, Reserve Bank of India.

State Government Expenditure: State government expenditure as a proportion of state GDP.
Source: Indian Public Finance Statistics, Ministry of Finance.

Newspaper Circulation: Number of registered newspapers in circulation.
Source: Registrar of Newspapers, Government of India.

Telephone Exchange: Number of telephone exchanges.
Source: Ministry of Information and Broadcasting, Government of India.

Sample and state codes

Andhra Pradesh (AP), Assam (AS), Bihar (BH), Chhattisgarh (CG), Delhi (DL), Gujarat (GJ), Haryana (HR), Himachal Pradesh (HP), Jammu and Kashmir (JK), Jharkhand (JH), Karnataka (KT), Kerala (KL), Madhya Pradesh (MP), Maharashtra (MH), Orissa (OS), Punjab (PJ), Rajasthan (RJ), Tamil Nadu (TN), Uttar Pradesh (UP), West Bengal (WB).

Measurement error and instrumental variable estimation

Assume that the true relationship between corruption and growth is $c_{it} = \alpha_i + \delta\beta_t + \gamma_1 \hat{y}_{it} + \varepsilon_{it}$. However the corruption variable has measurement error so that $\tilde{c}_{it} = c_{it} + \theta_{it}$ (where θ_{it} is the time varying measurement error). Because of measurement error we only observe $\tilde{c}_{it}$ and not true corruption c_{it}. So we estimate the model $\tilde{c}_{it} = \alpha_i + \delta\beta_t + \gamma_1 \hat{y}_{it} + \varepsilon_{it}$. While estimating this model using fixed effects we would difference the data and get

$\Delta\tilde{c}_{it} = \tilde{c}_{it} - \tilde{c}_{it-1} = \delta\Delta\beta_t + \gamma_1\Delta\hat{y}_{it} + \Delta\varepsilon_{it}$. The parameter estimate of interest would be, $\hat{\gamma}_1 = \frac{\text{cov}(\Delta\tilde{c}_{it},\Delta\hat{y}_{it})}{\text{var}(\Delta\hat{y}_{it})} = \frac{\text{cov}[\Delta(c_{it}+\theta_{it}),\Delta\hat{y}_{it}]}{\text{var}(\Delta\hat{y}_{it})} = \frac{\text{cov}(\Delta c_{it},\Delta\hat{y}_{it})}{\text{var}(\Delta\hat{y}_{it})} + \frac{\text{cov}(\Delta\theta_{it},\Delta\hat{y}_{it})}{\text{var}(\Delta\hat{y}_{it})}$ and $p\lim\hat{\gamma}_1 = \gamma_1 + (bias)$. Therefore, estimating the model using OLS would yield biased estimates. If we use rainfall instrument Z_{it} that is correlated with $\Delta\hat{y}_{it}$ but orthogonal (or uncorrelated) to $\Delta\theta_{it}$, $\Delta\beta_t$ and $\Delta\varepsilon_{it}$ then $\text{cov}(Z_{it},\ \Delta\theta_{it}) = \text{cov}(Z_{it},\ \Delta\beta_t) = \text{cov}(Z_{it},\ \Delta\varepsilon_{it}) = 0$. Then we would get, $\hat{\gamma}_1^{IV} = \frac{\text{cov}(Z_{it},\Delta\tilde{c}_{it})}{\text{cov}(Z_{it},\Delta\hat{y}_{it})} = \frac{\text{cov}[Z_{it},\Delta(c_{it}+\theta_{it})]}{\text{cov}(Z_{it},\Delta\hat{y}_{it})} = \frac{\text{cov}(Z_{it},\Delta c_{it})}{\text{cov}(Z_{it},\Delta\hat{y}_{it})} + \frac{\text{cov}(Z_{it},\Delta\theta_{it})}{\text{cov}(Z_{it},\Delta\hat{y}_{it})} = \frac{\text{cov}(Z_{it},\Delta c_{it})}{\text{cov}(Z_{it},\Delta\hat{y}_{it})}$ and $p\lim\hat{\gamma}_1^{IV} = p\lim\frac{\text{cov}(Z_{it},\Delta c_{it})}{\text{cov}(Z_{it},\Delta\hat{y}_{it})} = p\lim\frac{\text{cov}[Z_{it},(\Delta\beta_t+\gamma_1\Delta\hat{y}_{it}+\Delta\varepsilon_{it})]}{\text{cov}(Z_{it},\Delta\hat{y}_{it})} = \gamma_1$ since $\text{cov}(Z_{it},\ \Delta\beta_t) = \text{cov}(Z_{it},\ \Delta\varepsilon_{it}) = 0$. Therefore, the IV strategy could potentially remedy the measurement error problem with 2008 corruption data.